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# Clinical Study of the Deaf Child

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In recent years, the question of countermeasures for the welfare of the disabled and the insane has become of great importance in this country. However, there are extremely few medical studies available on the speech impediments caused by hearing disorders, notwithstanding their long history. The present study aims at taking a comprehensive view from the standpoint of rehabilitation on how to take measures to counter such children with physical handicaps. The subjects were 50 deaf children who had undergone the speech training by lip reading alone. The method employed in this study consisted of the air-conduction test, bone-conduction test, and otological exmination, from which efforts were made to classify the hearing types and the hearing disorders types they had possessed. In addition to these, the articulation intelligibility test, conversation intelligibility test; sound spectrographic test and X-ray motion film test of articulatory movements were carried out. What can be said from the results of these tests is that the speech disorders of the deaf children are abnormalities arising from the speech training by lip reading alone in utter disregard of their residual hearing acuity. In order, therefore, to diminish these disorders, positive application of the acoupedic treatment, which is a speech therapy using residual hearing acuity from early childhood, will be highly recommendable in this country also.

In recent years, especially after Word War II, rehabilitation of the disabled has become an important social problem in this country. In the field of Oto-Rhino-Laryngology, it has come to be known that some of the children with hearing disorders would assuredly be saved from falling into social refuse, if they were found at an early stage and given proper training in time. How to take measures to counter such children with speech impediments caused by hearing disorders now constitutes a great question of the day. In view of the prevailing situation, the author has made a study of their speech and speech rehabilitation, the results of which are here reported as follows.

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## GENERAL REMARKS

In Japan, accounts on the deaf-mute are found in records of as early as Nana period (C. 712–784), but they are all on literary themes. For a long time after this, neither scientific study nor speech education of the deaf-mute had been pursued. It was in the middle of Meiji era (C. 1893) that, through the introduction of Oto-Rhino-Laryngology, scientific study of the deaf-mute began in Japan[1]. At the beginning the study was limited to introducing actual ways and methods of studying the deaf-mute in foreign countries, but, later, scientific study of the disabled became possible in Japan, too, so that many studies, pathological, clinical, or genetical are presently available in this country.

Speech education of the deaf-mute in Japan likeweise began in the latter days of Meiji era, but it was in no way systematic. Deaf-education had not yet been taken up as a Government policy in this country. At this very juncture, ALEXANDER GRAHAM BELL[2] came to Japan in 1898 (31 st year of Meiji), when he lectured on the necessity of Japan's adopting the oral method in the deaf education, pointing out its neglected state in this country. In Japan, the deaf education spread nationwide in time. However, in speech education of the deaf, both oral and manual methods had still been employed separately just as in Europe and America till the latter days of Taisho era (C. 1925), when superiority of the oral method was recognized in Japan, too, and today reports on cases educated by the oral method are available ad. lib. This oral method has now spread so wide that the present unified deaf education is conducted all over the country[3)4)5)6)].

In Japan, phonetical study of the deaf-mute speech began as late as around the 11th year of Showa (C. 1936–1942)[7)8)9)10)]. After World War II, accelerated by progress in electronics, phonetical study has greatly advanced in Japan, too, so that singularity of the speech sounds of the deaf-mute has come to be known gradually. Simultaneously with this, accurate hearing test of the deaf-mute became possible, and the fact was revealed that some of those who had been previously considered as deaf-mutes retained a fair amount of hearing acuity. A change of plan in the speech education of such persons is therefore urgently called for.

## OBJECT

Material: 5 groups, each consisting of 10 deaf children of 9, 10, 11, 12, 13 years of age. Total: 50 (25 male, 25 female). All these young deaf children had received no speech education before they came to the age of 7, when they were admitted to the deaf asylum, and for the

first time given speech education there by the lip-reading method alone, irrespective of the presence of hearing acuity. Their intelligence was normal, school attainments above medium.

## METHOD

The residual hearing acuity was exactly grasped through the hearing test. Speech faculty was ascertained by means of the articulation and pronunciation intelligibility test, and conversation intelligibility test. Besides, soundspectrograph was taken in order to show the phonetical features of these deaf children and cinefluorographic investigation was made in order to show their articulatory behavior.

Hearing test: Air-conduction test and bone-conduction test of the deaf children were carried out after they had fully understood the test sounds. Articulation and pronunciation intelligibility test: The subjects were so led as to read in the ordinary conversational way a test list containing 100 monosyllabic Japanese words, and every articulated sound was electrically tape-recorded in a sound-proof room.

Degrees of intelligibility of each articulated or pronounced sound were judged by a group of 5 listeners with normal hearing acuity, the recorded sounds having been reproduced so that each sound registered 60 phons at a distance of 1 meter from the group. In the judgment, the maximum and minimum points given by the group were excluded and the mean of the points given by the medium 3 were taken up as calculating standard of intelligibility. Conversation intelligibility test: The speech faculty test sentences for deaf children by TAGUCHI[11] were used. The speech sounds were electrically recorded in the same way as in the case of the articulation and pronunciation intelligibility test, and judgment was given on the basis of the recorded sounds.

Test sentences: ··· Grade ··· Class ··· Name.
Konnichiwa yoitenkidesu. gokigen ikagadesuka. Asobini kimashita. Mata Watakushino iyeyemo asobini kitekudasai. Sayonara.

Judgment: Grade Ⅰ intelligible
〃 Ⅱ occasionally unintelligible
〃 Ⅲ intelligible if the listeners know the theme
〃 Ⅳ occasionally intelligible
〃 Ⅴ entirely unintelligible

Sound Spectrographic test: Electrically recorded speech sounds used in the articulation intelligibility test were analized through Lyon Company's sound spectrograph. As control, analysis of the speech sound of children with normal hearing acuity was also carried out. The test words employed in the analysis were the vowels, and k, s, t, r series.

Cinefluorographic slow motion picture test through X-ray television: A group of 10 children consisting of 5 with a fair degree of articulating faculty and 5 with a poor degree were picked up from the 50 subjects

and put to a close examination of their articulating behaviors. In addition, test by 16 mm film slow motion picture through X-ray television was carried out. The words employed in the test were the vowels, and k, s, t, r series.

## RESULTS

*1) Hearing Acuity & Otological Findings*

Average hearing loss and auditory type were obtained from the results of the air conduction hearing test and bone conduction hearing test carried out on the 50 subjects. The above result and our otological view determined the kind of hearing disorders they had. These findings are shown on Table (1). Frequency of occurrence of the average hearing

Table (1)

Aubitory type
- high frepuency disorder ——＼
- levell ——————————— —
- low frequency disorder ——／
- non measurable ————— ○

Classification of hearing loss
- conductive hearing disorders ····· C
- sensitive hearing disorders ····· S
- mixed hearing disorders ····· M

| No. | hearing loss db | auditory type | classification of hearing loss | No. | hearing loss db | auditory tvpe | classification of hearing loss |
|---|---|---|---|---|---|---|---|
| 1 | 76 | — | C | 26 | 76 | ＼ | M |
| 2 | 86 | ＼ | S | 27 | 53 | ＼ | M |
| 3 | 41 | — | C | 28 | 52 | ／ | C |
| 4 | 90up | 0 | S | 29 | 74 | — | M |
| 5 | 49 | — | C | 30 | 72 | ＼ | S |
| 6 | 90 | ＼ | S | 31 | 50 | — | C |
| 7 | 90up | 0 | S | 32 | 61 | — | C |
| 8 | 85 | ＼ | S | 33 | 47 | — | C |
| 9 | 40 | — | C | 34 | 49 | ／ | M |
| 10 | 36 | ＼ | S | 35 | 82 | ＼ | S |
| 11 | 40 | — | C | 36 | 62 | — | M |
| 12 | 36 | ／ | C | 37 | 90up | 0 | S |
| 13 | 40 | ／ | C | 38 | 90up | 0 | S |
| 14 | 65 | ＼ | M | 39 | 80 | — | M |
| 15 | 25 | — | C | 40 | 68 | — | S |
| 16 | 42 | — | M | 41 | 50 | — | C |
| 17 | 76 | ＼ | M | 42 | 90up | 0 | S |
| 18 | 81 | ＼ | S | 43 | 50 | ＼ | M |
| 19 | 90up | — | S | 44 | 78 | ／ | M |
| 20 | 65 | ＼ | S | 45 | 80 | ／ | S |
| 21 | 57 | — | M | 46 | 90up | 0 | S |
| 22 | 49 | — | C | 47 | 63 | ＼ | M |
| 23 | 62 | — | M | 48 | 63 | ＼ | M |
| 24 | 52 | — | M | 49 | 90up | 0 | S |
| 25 | 88 | — | S | 50 | 90up | ＼ | S |

loss is shown in Table (2), viz:

| | | |
|---|---|---|
| 90 db up | 10 childrens | (20%) |
| 80 db 〃 | 18 〃 | (36%) |
| 59 db under | 17 〃 | (34%) |
| 49 db 〃 | 11 〃 | (22%) |

An investigation into the nature of the children's difficulty in hearing revealed that 14 (28%) suffered from what was supposed to be conductive hearing disorders, 20 (40%) from what was considered to be sound-sensation hearing disorders, 16 (32%) from what was taken as mixed.

Table (2)

| Hearing loss db | Cases |
|---|---|
| — 39 | 2 |
| 40 — 49 | 9 |
| 50 — 59 | 6 |
| 60 — 69 | 9 |
| 70 — 79 | 6 |
| 80 — 89 | 8 |
| 90 — | 10 |
| Total | 50 |

*2) Articulation and Pronunciation Intelligibility*

In this test, the maximum and the minimum points given by 2 of the 5 listeners being excluded the degree of intelligibility obtained is indicated by the arithmetical mean of the points given by the medium 3 as shown on Table (3).

Table (3) Articulation & pronunciation intelligibility

| 9 year old | % | 10 year old | % | 11 year old | % | 12 year old | % | 13 year old | % |
|---|---|---|---|---|---|---|---|---|---|
| No. 1 | 49.3 | 11 | 55.3 | 21 | 30.0 | 31 | 67.3 | 41 | 73.7 |
| 2 | 47.7 | 12 | 36.7 | 22 | 47.8 | 32 | 60.0 | 42 | 42.7 |
| 3 | 47.7 | 13 | 45.0 | 23 | 37.3 | 33 | 46.3 | 43 | 37.7 |
| 4 | 27.7 | 14 | 27.0 | 24 | 56.0 | 34 | 59.7 | 44 | 16.7 |
| 5 | 58.7 | 15 | 17.7 | 25 | 76.3 | 35 | 36.7 | 45 | 21.3 |
| 6 | 39.3 | 16 | 8.3 | 26 | 31.7 | 36 | 28.0 | 46 | 18.0 |
| 7 | 30.0 | 17 | 19.3 | 27 | 30.3 | 37 | 36.0 | 47 | 34.5 |
| 8 | 20.3 | 18 | 18.3 | 28 | 35.0 | 38 | 34.0 | 48 | 48.7 |
| 9 | 60.3 | 19 | 16.7 | 29 | 28.0 | 39 | 15.7 | 49 | 16.7 |
| 10 | 46.3 | 20 | 29.0 | 30 | 30.3 | 40 | 33.7 | 50 | 17.3 |
| Average | 42.7 | | 28.3 | | 40.3 | | 41.7 | | 32.7 |

What is gathered from the above result is that no particular interrelation exists between age and intelligibility, senior children not necessarily giving better intelligibility than juniors.

Further, frequency of occurrence of intelligibility being as exhibited on Table (4), intelligibility obtained from the largest majority of cases in the present test marked 31—40%, 11 (22%) children. Those whose intelligibility gave 50% and less counted 41 (82%), of whom 32 (64%) showed less than 40%. On the other hand, those who gave intelligibility 50% and up counted only 9 (18%), of whom 2 (4%) marked 70% and up. Not a single child was found to have intelligibility 80% and up.

Table (4) Incidence of articulation & pronunciation intelligibility

| % | Cases |
|---|---|
| — 10 | 1 |
| 11 — 20 | 10 |
| 21 — 30 | 10 |
| 31 — 40 | 11 |
| 41 — 50 | 9 |
| 51 — 60 | 6 |
| 61 — 70 | 1 |
| 71 — | 2 |
| Tatal | 50 |

Table (5) Speech sound and articulation & pronunciation intelligibility

| | | | |
|---|---|---|---|
| Vowel | 76.9% | P | 64.3% |
| K | 58.0 | W | 64.7 |
| S | 30.4 | Kya | 15.6 |
| T | 58.0 | Sha | 26.7 |
| N | 58.0 | Cha | 13.3 |
| H | 40.9 | Nya | 17.6 |
| M | 62.0 | Hya | 6.9 |
| Y | 42.7 | Mya | 10.0 |
| R | 63.9 | Rya | 11.9 |
| G | 19.5 | Gya | 4.9 |
| Z | 13.2 | Ja | 5.1 |
| D | 32.7 | Bya | 18.2 |
| B | 38.8 | Pya | 16.4 |

Table (6) Mishearing trend

| | | | | | |
|---|---|---|---|---|---|
| A | Ha | Za | Sha | Rya | Ya |
| I | Chi, Hi | Zi | Shi, Chi | Ryu | ? |
| U | Hu | Zu | Shu. Su | Ryo | Re |
| E | He | Ze | She, Se | Gya | Zya, Kya |
| O | Ho | Zo | Sho, Cho | Gyu | Zyu, Chu |
| Ka | Ta, Ga | Da | Ta | Gyo | Zyo, Cho |
| Ki | Chi, Gi | De | Chi | Zya | Pya, Rya |
| Ku | Tsu, Gu | Do | Tsu | Zyu | Pyu, Byu |
| Ke | Ge | Ba | Pa | Zyo | Pyo, Byo |
| Ko | Go | Bi | Pi | Bya | Pya, Rya |
| Sa | Sha | Bu | Pu | Byu | Pyu, Ryu |
| Shi | I | Be | Pi, Bi, Pe | Byo | Pyo, Ryo |
| Su | Shu | Bo | Po | Pya | ? |
| Se | She | Sha | Cha | Pyu | ? |
| So | Sho | Shu | Chu | Pyo | ? |
| Hi | Shi | Sho | Cho | | |
| Yu | Chu, Shu, Cha | Cha | Rya, Ya | | |
| Yo | So, Sho | Chu | Zyu, U | | |
| Ra | Ya | Cho | Zyo, Yo | | |
| Ri | I | Nya | Cha | | |
| Ru | Nu | Nyu | Shu | | |
| Re | E | Nyo | Sho | | |
| Ro | No | Hya | Sha, Rya | | |
| Ga | Ka | Hyu | Shu, Ryu | | |
| Gi | Ki | Hyo | Sho, Ryo | | |
| Gu | Ku | Mya | Bya, Kya. Ra | | |
| Ge | He, E, Ke | Myu | Byu, Pyu, Ryu | | |
| Go | Ko | Myo | Byo, Hyo, Ryo | | |

Table (7)

Conversation intelligibility

| No. \ Grade | I | II | III | IV | V | No. \ Grade | I | II | III | IV | V |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 0 | | | | 26 | | | 0 | | |
| 2 | | | 0 | | | 27 | | 0 | | | |
| 3 | | 0 | | | | 28 | | | 0 | | |
| 4 | | | 0 | | | 29 | | | | 0 | |
| 5 | 0 | | | | | 30 | | | 0 | | |
| 6 | | | 0 | | | 31 | 0 | | | | |
| 7 | | | | 0 | | 32 | 0 | | | | |
| 8 | | | | 0 | | 33 | | 0 | | | |
| 9 | 0 | | | | | 34 | 0 | | | | |
| 10 | | 0 | | | | 35 | | 0 | | | |
| 11 | 0 | | | | | 36 | | | 0 | | |
| 12 | | 0 | | | | 37 | | | 0 | | |
| 13 | | | 0 | | | 38 | | | | 0 | |
| 14 | | | 0 | | | 39 | | | | | 0 |
| 15 | | | 0 | | | 40 | | | | | 0 |
| 16 | | | | 0 | | 41 | 0 | | | | |
| 17 | | | | 0 | | 42 | | 0 | | | |
| 18 | | | 0 | | | 43 | | 0 | | | |
| 19 | | | | 0 | | 44 | | | | 0 | |
| 20 | | | 0 | | | 45 | | | 0 | | |
| 21 | | 0 | | | | 46 | | | | 0 | |
| 22 | | 0 | | | | 47 | | | 0 | | |
| 23 | | | 0 | | | 48 | | 0 | | | |
| 24 | 0 | | | | | 49 | | | | 0 | |
| 25 | 0 | | | | | 50 | | | | 0 | |

Table (8)

Incidence of conversation intelligibility

| Age \ Grade | I | II | III | IV | V |
|---|---|---|---|---|---|
| 9 | 2 | 3 | 3 | 2 | 0 |
| 10 | 1 | 1 | 5 | 3 | 0 |
| 11 | 2 | 3 | 4 | 1 | 0 |
| 12 | 3 | 2 | 2 | 1 | 2 |
| 13 | 1 | 3 | 2 | 4 | 0 |
| Total | 9 | 12 | 16 | 11 | 2 |

Results of the test made on 50 subjects having been grouped together by speech sounds, articulation and pronuciation intelligility of every speech sound obtained was as shown on Table (5), vowel sounds giving the highest, 76.9%, Gya series the lowest, 4.9%. Phonetically classified 100 words used in the test gave the following percentage.

Voiceless sounds 76.9−30.4%
Voiced & semi-voiced sounds 64.3−13.2%
Contracted sounds 26.7− 4.9%

All consonant sounds having been classified by articulation points, intelligibility obtained presented the following percentage:

Labial sounds (b. p. m. w) 64.7−36.8%
Dental 〃 (d. n. s. r. sh. ch) 63.9−13.3%
Palatal 〃 (k. g) 58.0−19.5%
Aspirate 〃 (h) 40.9%

Classified by articulation movements, consonant sounds gave the following percentage of intelligibility.

Elastic sounds (r) 63.9%
Nasal 〃 (m. n) 62.0−58.0%
Plosive 〃 (p. b. t.d. k. g) 64.3−19.5%
Fricative 〃 (s.sh) 40.9−26.7%
Plosive-fricative sounds (ch. di) 32.7−13.3%

Further, an investigation into the nature of the subject's speech sounds which were judged misheard by the listeners revealed results as indicated on Table (6). It may therefore be drawn from these results

Table (9) Sonagraphic findings and intelligibility

| No. | Age | Sex | A | I | U | E | O | Ka | Ki | Ku | Ke | Ko | Sa | Shi | Su | Se | So | Ta | Chi | Tsu | Te | To | Ra | Ri | Ru | Re | Ro | Hearing loss db | Articulation & Pronunciation Intelligibility % | Conversation Intelligibility |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9 | ♀ | − | + | − | + | − | ++ | ++ | ++ | ++ | ++ | ++ | + | + | + | + | + | + | + | + | + | ++ | ++ | ++ | ++ | ++ | 76 | 49.3 | Ⅱ |
| 2 | 〃 | ♀ | − | + | − | − | − | + | ++ | + | + | + | + | ++ | ++ | + | + | + | ++ | ++ | + | + | + | + | + | + | + | 86 | 47.7 | Ⅲ |
| 4 | 〃 | ♀ | − | + | + | − | − | ++ | +++ | +++ | ++ | ++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ | ++ | ++ | ++ | + | ++ | ++ | ++ | + | 90up | 27.7 | Ⅲ |
| 11 | 10 | ♀ | − | − | − | − | − | − | − | + | − | − | ++ | ++ | ++ | ++ | ++ | − | + | + | − | − | − | − | − | − | − | 40 | 55.3 | Ⅰ |
| 12 | 〃 | ♂ | − | − | − | − | − | − | + | − | − | − | ++ | +++ | +++ | ++ | +++ | + | ++ | ++ | + | + | + | + | ++ | ++ | ++ | 36 | 36.7 | Ⅱ |
| 13 | 〃 | ♀ | − | + | − | − | − | − | + | − | − | − | +++ | +++ | +++ | ++ | ++ | + | +++ | ++ | + | + | + | + | + | + | + | 40 | 45.0 | Ⅲ |
| 14 | 〃 | ♂ | − | + | − | + | − | + | + | + | + | + | +++ | ++ | +++ | +++ | +++ | + | +++ | +++ | +++ | + | +++ | +++ | +++ | +++ | +++ | 65 | 27.0 | Ⅲ |
| 18 | 〃 | ♂ | − | + | + | + | − | + | ++ | ++ | ++ | + | ++ | ++ | + | ++ | + | + | +++ | +++ | ++ | + | + | +++ | +++ | ++ | + | 81 | 18.3 | Ⅲ |
| 21 | 11 | ♂ | − | + | − | + | + | +++ | ++ | + | + | + | +++ | +++ | +++ | +++ | +++ | + | +++ | +++ | +++ | + | + | + | + | + | + | 57 | 30.0 | Ⅱ |
| 22 | 〃 | ♂ | − | − | − | − | − | + | + | + | + | + | + | + | ++ | +++ | +++ | + | + | + | + | + | + | + | + | + | + | 49 | 47.8 | Ⅱ |
| 28 | 〃 | ♀ | − | + | + | + | + | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | + | + | + | ++ | + | ++ | + | + | + | + | 52 | 35.0 | Ⅲ |
| 30 | 〃 | ♀ | − | + | + | + | − | + | + | + | + | + | +++ | +++ | +++ | +++ | +++ | + | + | + | + | + | + | + | + | + | + | 72 | 30.0 | Ⅲ |
| 31 | 12 | ♂ | − | − | − | − | − | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | 50 | 67.3 | Ⅰ |
| 32 | 〃 | ♀ | − | + | − | − | − | − | − | − | − | − | − | ++ | ++ | ++ | ++ | + | +++ | +++ | + | + | − | − | ++ | ++ | ++ | 61 | 60.0 | Ⅰ |
| 36 | 〃 | ♂ | − | + | + | + | + | + | + | − | + | + | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | + | + | + | + | 62 | 28.0 | Ⅲ |
| 41 | 13 | ♀ | − | − | − | − | − | + | + | + | + | + | ++ | ++ | ++ | ++ | ++ | + | + | + | + | + | + | + | + | + | + | 50 | 73.7 | Ⅰ |
| 42 | 〃 | ♂ | + | + | − | + | + | + | + | + | + | + | ++ | +++ | ++ | ++ | ++ | ++ | ++ | ++ | + | + | ++ | +++ | +++ | ++ | +++ | 90up | 42.7 | Ⅱ |
| 43 | 〃 | ♂ | − | − | − | + | + | +++ | +++ | +++ | +++ | +++ | ++ | ++ | ++ | ++ | ++ | +++ | +++ | +++ | +++ | +++ | + | ++ | ++ | + | + | 50 | 37.7 | Ⅱ |
| 44 | 〃 | ♂ | + | + | − | + | + | +++ | +++ | +++ | +++ | +++ | ++ | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | ++ | ++ | ++ | ++ | ++ | 78 | 16.7 | Ⅳ |
| 45 | 〃 | ♀ | − | − | + | + | + | +++ | +++ | +++ | +++ | + | ++ | +++ | +++ | ++ | ++ | + | +++ | +++ | +++ | +++ | + | ++ | +++ | + | + | 80 | 21.3 | Ⅲ |
| 46 | 〃 | ♀ | + | + | − | + | + | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | + | + | + | + | + | 90up | 18.0 | Ⅳ |
| 47 | 〃 | ♂ | − | + | − | − | + | + | + | ++ | ++ | + | +++ | +++ | +++ | +++ | +++ | + | + | ++ | + | + | +++ | +++ | +++ | +++ | +++ | 63 | 34.5 | Ⅲ |
| 48 | 〃 | ♀ | + | + | − | − | − | ++ | + | + | + | + | ++ | + | ++ | ++ | ++ | + | + | + | + | + | ++ | ++ | ++ | ++ | ++ | 63 | 48.7 | Ⅱ |
| 49 | 〃 | ♂ | + | + | + | + | + | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | + | ++ | ++ | ++ | + | 90up | 16.7 | Ⅳ |
| 50 | 〃 | ♀ | + | + | + | − | + | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ | ++ | ++ | ++ | 90up | 17.3 | Ⅳ |

that mishearing was caused by abnormal articulation of consonant part of the syllables. In most cases succeeding vowels having been normally pronounced, this phenomenon presents an aspect of liaison disorder.

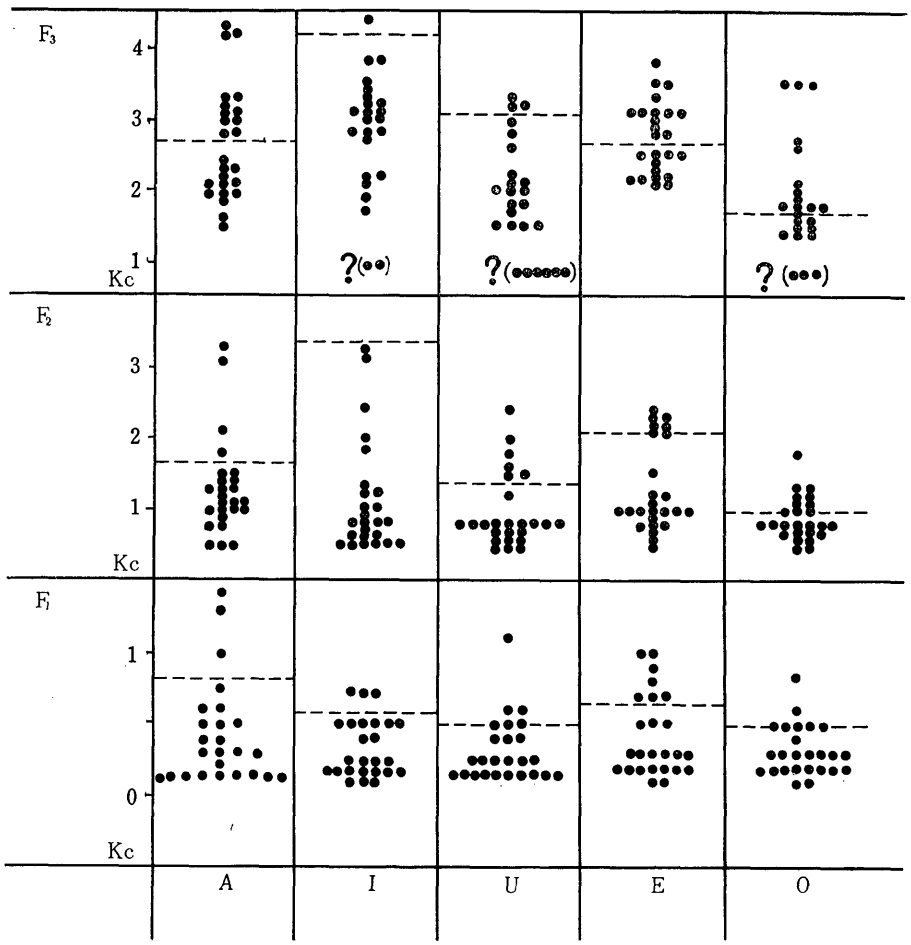
*3) Conversation Intelligibility*

The results of the test for conversation intelligibility is as shown on Table (7). It is otherwise classified by school grades as given on Table (8); i. e. those children coming under grade I (intelligible) and grade II (occasionally unintelligible), who are not considered to find difficulty in daily conversation, count 21 (42%), 9 of whom belonging to grade I. No distinctive trend has been observed in any of the school grades.

On the contrary, those children coming under grade III (intelligible if the listeners know the theme), grade IV (occasionally intelligible),

Table (10) Volwel formant

(----------) Normal average formant



and grade V (entirely unitelligible), who are considered to find difficulty in daily conversation, count 29 (58%), 2 of whom belonging to grade V.

*4) Sound Spectrographic Study*

In this test, 25 children randomly chosen from among the 50 were used as subjects. Their age, sex, hearing acuity, articulation and pronunciation intelligibility, conversation intellibigility are displayed on Table (9).

Of these subjects, 10 had shown articulation and pronunciation intelligibility 40% up; 15 less than 40%. As for conversation intelligibility, 11 had given a comparatively good result (grade I, grade II); 14 a comparatively bad result (grade III, grade IV).

Sound spectrogram (Sonagram) of each of the vowel sounds pronounced and consonant sounds of k, s, t, r series articulated by the 25 children was subjected to a close examination with special reference, in vowel sounds, to formant and murmur element; in consonant sounds, to spike fill and fill, shifting portion, and succeeding vowel sounds.

Examination giving results as exhibited on Table (10), (11), (12), it is noted that there developed the following phenomena in the test.

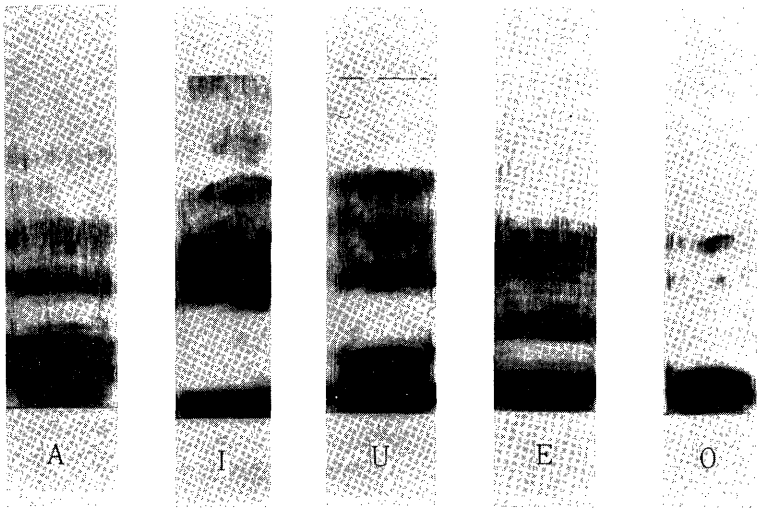
Table (11) consonant wave

| | Ka | ki | Ku | Ke | Ko | Sa | Si | Su | Se | So | Ta | Chi | Tu | Te | To | Ra | Ri | Ru | Re | Ro |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Preceeding wave | 6 | 5 | 4 | 3 | 7 | 4 | 4 | 4 | 4 | 4 | 3 | 5 | 5 | 3 | 4 | 2 | 4 | 4 | 4 | 2 |
| Weakness | 9 | 11 | 13 | 12 | 9 | 9 | 9 | 9 | 9 | 7 | 14 | 16 | 15 | 13 | 13 | 2 | 1 | 1 | 2 | 2 |
| strengthen | — | — | — | — | — | 1 | 2 | 3 | 2 | 1 | 1 | — | — | — | 1 | 6 | 6 | 9 | 9 | 8 |
| shortening | 1 | 2 | 2 | 2 | 2 | 7 | 6 | 6 | 8 | 8 | 10 | 8 | 7 | 9 | 8 | — | — | — | — | — |
| lengthening | 4 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| disappearance | 6 | 6 | 7 | 6 | 6 | 7 | 9 | 11 | 9 | 10 | 1 | 8 | 10 | 1 | 1 | 4 | 4 | 4 | 3 | 3 |
| division | 3 | 4 | 2 | 2 | 4 | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — |

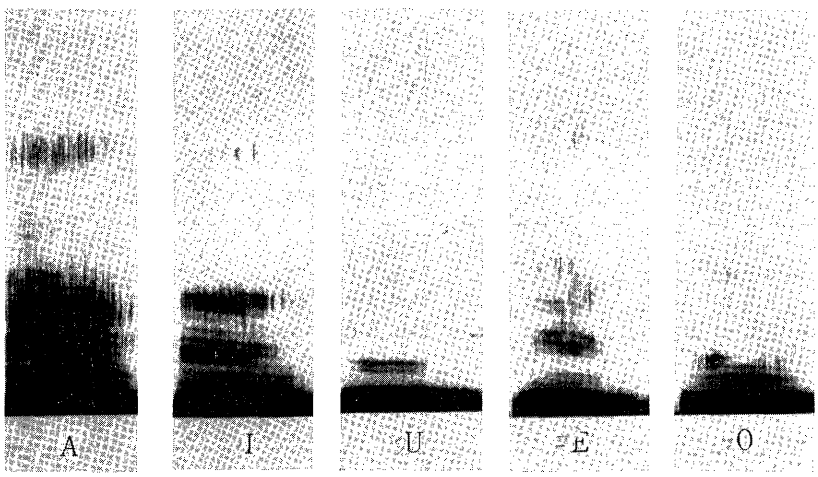
Table (12)

| | Ka | Ki | Ku | Ke | Ko | Sa | Shi | Su | Se | So | Ta | Chi | Tsu | Te | To | Ra | Ri | Ru | Re | Ro |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| transitional part | | | | | | | | | | | | | | | | | | | | |
| diminution | 10 | 9 | 6 | 9 | 10 | 1 | 1 | 1 | 1 | 1 | 12 | 13 | 12 | 12 | 11 | — | — | — | — | — |
| expansion | 1 | 2 | 4 | 4 | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| disappearance | 9 | 6 | 5 | 4 | 5 | 20 | 20 | 19 | 20 | 19 | 9 | 8 | 10 | 8 | 8 | 1 | 1 | 1 | 1 | 1 |
| murmurization | 5 | 4 | 5 | 4 | 3 | 4 | 4 | 4 | 5 | 5 | 2 | 1 | 1 | 2 | 1 | 8 | 8 | 7 | 7 | 7 |
| succeeding vowel | | | | | | | | | | | | | | | | | | | | |
| disappearance | — | — | — | — | — | — | 3 | 2 | — | — | — | — | — | — | — | — | — | — | — | — |
| murmurization | 5 | 5 | 9 | 5 | 8 | 4 | 7 | 8 | 3 | 4 | 4 | 6 | 7 | 4 | 6 | 4 | 6 | 10 | 5 | 5 |

Fig. 1.



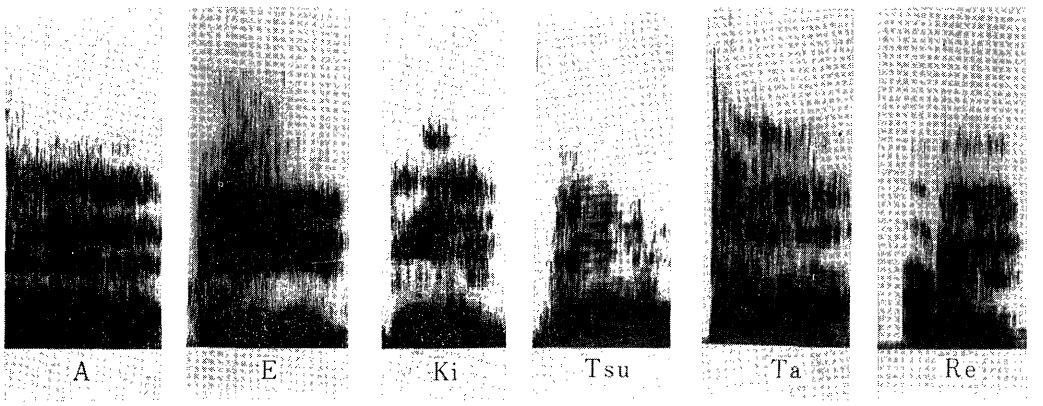

Normal




Deaf-mutism

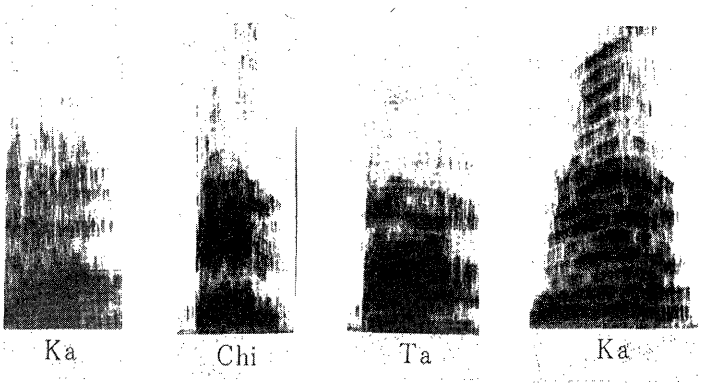
1. In vowel formant, shift into low frequency area of the first formant and the second formant ····· Fig. (1)
2. Disappearance of distinction of vowel formant between the five vowel sounds ····· Fig (1)
3. Emergence of murmur element considered hoarse voice in both vowel and consonant sounds ····· Fig. (2)
4. In consonant sounds, preceeding wave and shortening, lengthening, disappearance, weakening, strengthening, break up of spike fill and fill ····· Fig. (3)
5. Diminution, expansion, disappearance, murmur element of shifting portion ····· Fig. (4).

Fig. 2.

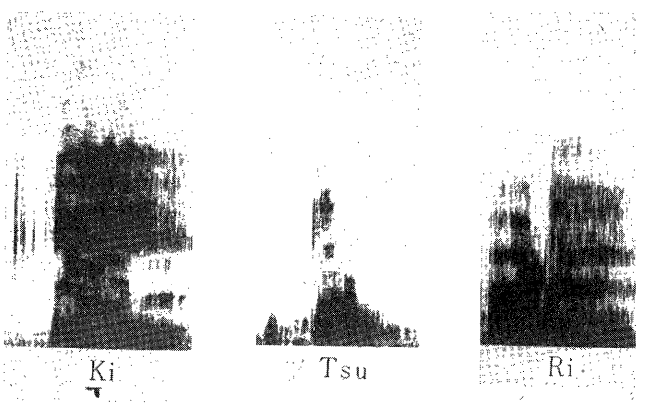



murmurization

Fig. 3.

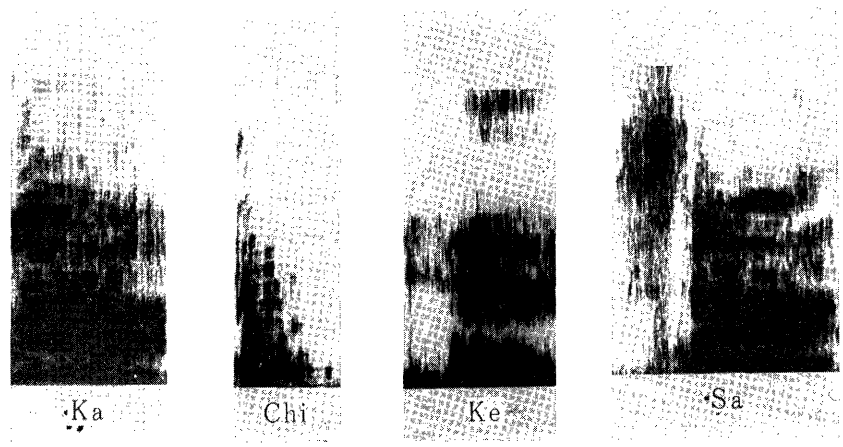



disappearance shortening weakness lengthening



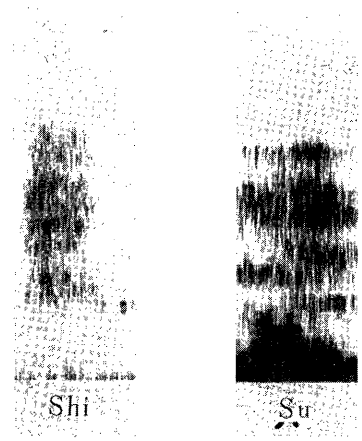

division strengthen preceeding wave

Fig. 4.




6. Disappearance, murmur element of succeeding vowel sound……Fig. (5).

Fig. 5.




Further, based on the viewpoint of sonagraphic findings and articulation and pronunciation intelligibility combined, the following criteria were laid down.

a. Abnormalities detected in sonagram, and misheard …… (卄)
b. Slight abnormalities detected in sonagram, and heard distorted …… (十)
c. Slight abnormalities detected in sonagram, but heard comparatively accurately …… (+)
d. Considered almost normal …… (−)

Table (9) shows results of the investigation carried out in accordance with the above criteria, together with residual hearing acuity, articulation and pronunciation intelligibility and conversation intelligibility.

It is drawn from the above results that the bigger the residual hearing acuity is, the sonagraphic findings and clearness of speech sounds. This phenomenon of correlativity is also found to exist between residual hearing acuity and pronuciation intelligibility or conversation intelligibility.

In sonagraphic examination, murmur element as well as frequency

element of sound in almost every case, and the fact is revealed that the stronger the residual hearing acuity is, the weaker is the murmur element.

*5) Observation by Clinefluorographic Slow Motion Picture Test through X-ray TV*

10 subjects consisting of a group of 5 with comparatively intelligible speech sounds and another of the same number with comparatively unintelligible speech sounds were picked up from among the deaf children according to the results they had given in the conversation intelligibility test.

Age, sex, hearing acuity, articulation and pronunciation intelligibility and conversation intelligibility of the subjects are displayed on Table (13).

Table (13)

| No. | Age | Sex | Hearing loss db | Articulation & Pronunciation Intelligibiiity % | Conversotion Intelligibility |
|---|---|---|---|---|---|
| 1 | 9 | ♀ | 76 | 49.3 | Ⅱ |
| 5 | 9 | ♂ | 49 | 58.7 | Ⅰ |
| 12 | 10 | ♂ | 36 | 36.7 | Ⅱ |
| 13 | 10 | ♀ | 40 | 45.0 | Ⅲ |
| 14 | 10 | ♂ | 65 | 27.0 | Ⅲ |
| 15 | 10 | ♂ | 25 | 17.7 | Ⅲ |
| 22 | 11 | ♂ | 49 | 47.8 | Ⅱ |
| 26 | 11 | ♀ | 76 | 31.7 | Ⅲ |
| 27 | 11 | ♂ | 53 | 30.3 | Ⅱ |
| 28 | 11 | ♂ | 74 | 28.0 | Ⅳ |

The testing installations comprised Philip's Fluorescence Amplification X-ray Cine (x-ray TV) connected with Bollex's 16 mm Motion Picture.

Speech sounds of vowels and k, s, t, r series were used as test sounds, and aspects of articulating behavior were filmed from the right and left directions.

Observation was made, as regards vowel sounds, on position and form of the tongue at the moment of pronunciation performance; as regards consonant sounds, on articulation point and movement of the tongue at the moment of articulation performance, as well as on position and form of the tongue at the moment of pronunciation performance of succeeding vowel sounds. Judgment was passed in accordance with the following criteria.

Vowel sounds:

1. Abnormalities noticeable in both position and form of the tongue in pronouncing ····· (++)
2. Abnormalities noticeable either in position or in form ····· (+)

3. Almost normal ····· (−)

Consonant sounds :

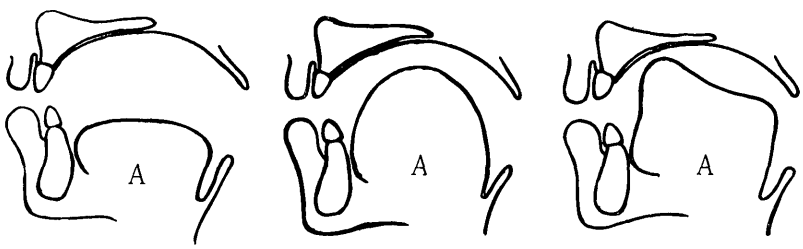
1. Abnormalities noticeable both in articulation point and movement of the tongue; in position and form of the tongue at the moment of pronunciation performance of succeeding vowel sounds ····· (++)
2. Abnormalities noticeable only in one of the two items ····· (+)
3. Almost normal ····· (−)

Observation giving results as exhibited on Table (14), it is noted that there exists a correlative trend between abnormality of articulation and lowness of intelligibility.

Table (14) Cinefluorographic findings and intelligibility

| No. | A | I | U | E | O | Ka | Ki | Ku | Ke | Ko | Sa | Si | Su | Se | So | Ta | Chi | Tu | Te | To | Ra | Ri | Ru | Re | Ro |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | − | − | − | ++ | − | − | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| 5 | − | − | − | − | − | − | − | − | − | − | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | ++ | ++ | ++ | ++ |
| 12 | − | − | + | − | − | − | − | − | + | − | ++ | + | ++ | ++ | + | − | + | − | − | − | + | + | + | + | + |
| 13 | − | − | + | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − |
| 14 | ++ | ++ | ++ | ++ | ++ | + | + | + | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | − | − | − | − | − |
| 15 | ++ | ++ | ++ | ++ | ++ | + | + | + | + | − | ++ | ++ | ++ | ++ | ++ | + | ++ | ++ | + | + | − | − | − | − | − |
| 22 | + | + | + | + | + | − | + | + | + | − | + | + | + | + | + | ++ | + | + | ++ | ++ | − | − | − | − | − |
| 26 | + | ++ | ++ | ++ | ++ | ++ | + | + | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| 28 | + | + | + | + | + | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | + | + | + | + | + |
| 29 | + | ++ | ++ | ++ | + | − | + | + | − | − | ++ | ++ | ++ | ++ | ++ | + | + | + | + | + | + | + | + | + | + |

Fig. 6.



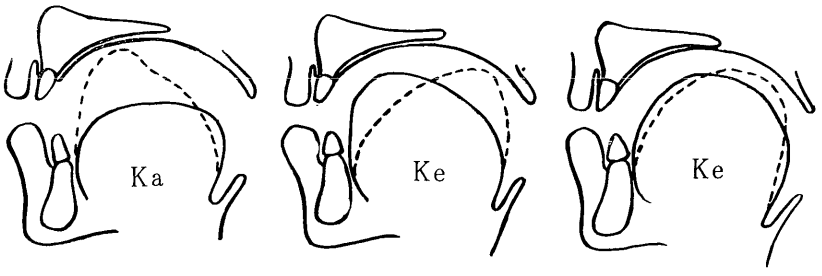

flattened form cylindrical form articulation point

An investigation into the forms of abnormal articulation revealed by the abves observation gives the following aspects.

Vowels : ····· Fig. (6).

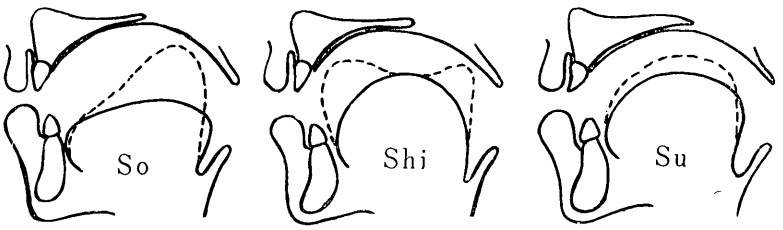
1. Back of the tongue flattened.
2. Back of the tongue approaching the palate in a cylindrical form.
3. Pronunciation point resembling articulation point of consonant sounds.

Fig. 7.



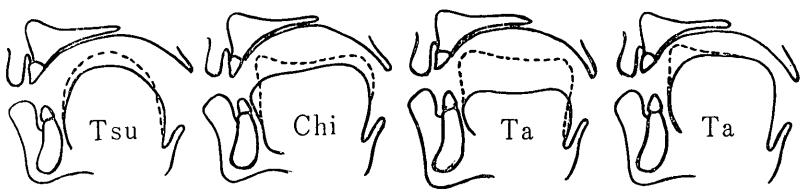

forward backward dropped motiliy

Fig. 8.




dackward broken into two parts cylindrical form for lack of sufficient motility

Fig. 9.




no articulation point articulation point located at two parts low position cylindrical form & lack of sufficient motility

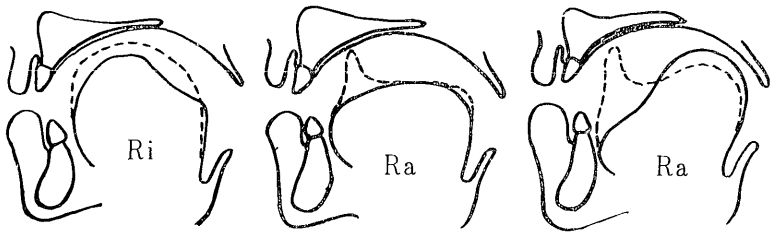
K series : ····· Fig. (7)

1. Articulation point moved forward in Ka, Ko.
2. Articulation point moved backword in Ki, Ku, Ke.
3. Motility dropped at the moment of pronunciation performance of succeeding vowel sounds.

S series : ····· Fig. (8)

1. Articulation point moved backward.
2. Articulation point enlarged or broken into two parts.
3. Back of the tongue raised in a cylindrical form for lack of sufficient motility of the tongue,

Fig. 10.




no articulation point dropped motility backward

T series : ····· Fig. (9)

1. Articulation point undetected in Ti, Tsu.
2. Articulation point located at two parts, i.e. tip and root of the tongue.
3. Tongue taking low position at the moment of pronunciation performance of succeeding vowel sounds in Ta, Te, To.
4. Back of the tongue raised in a cylindrical form at the moment of pronunciation performance of succeeding vowel sounds for lack of sufficient motility of the tongue.

R series : ····· Fig. (10)

1. No articulation point located.
2. Motility of the tongue lost at the moment of pronunciation performance of succeeding vowel sounds.
3. Root of the tongue raised backward, approaching the soft palate.

## DISCUSSION

Innumerable studies on the deaf-mute have been reported since the 16th century, but most of them are on genetical or pathohistological themes. Recently, audiometric studies have been introduced, and, today, reports of phenetical or speech patholgical studies on the deaf-mute have increased.

However, studies so far reported are only on one side of the deaf-mute, no systematic studies of them for their rehabilitation being available.

Therefore, in his effort to know how to conduct rehabilitation of deaf children, the author has carried out a systematic study of 50 deaf children from a speech pathological point of view.

In the following treatise, the author wishes to discuss and debate on the outcome of every test he has made, and ultimately take a comprehensive view of the whole experiment with special reference to rehabilitation of deaf children.

*1. Hearing acuity*

Ever since the time when the fact was revealed that deafness was due to hearing disorders, many hearing acuity tests have been undertaken. Early reports give information regarding rough tests executed by means of strong speech sound, murmur sound, instrument sounds, etc. Itard et el. attempted classification of the deaf-mute according to the results obtained.

However, the establishment of test method of hearing acuity through the medium of tuning fork, which was started by F. BEZOLD[12] (1893), marked a new turn in the way of hearing acuity test of the deaf-mute. This, together with later emergence of GARTON's pipe, went so far in time as to make it possible to quantitatively measure the hearing acuity of the deaf-mute.

Reports of tests made by BEZOLD-EDELMAN's, HARTMAN's tuning fork, or GARTON's pipe are available ad. lib. abroad. BEZOLD[12] found residual hearing acuity in 71.4% of his subjects, DENKER[13] in 60%, HASSLAUER[14] in 45.5%, BROCK[15] in 48.9%.

In Japan, there are the reports by YOSHII[16], HOSOYA[17], UCHIDA[18], NINOMIYA[19], YOSHIDA[20], et al., all of which demonstrated similar results to those of the foreign scholars.

Attempts at testing hearing acuity through the medium of audiometer had already been made in around 1925, but the data obtained were not so accurate as to warrant reliability on them. It was only after World War II that, accelerated by progress in science, accurate hearing test by audiometer became possible, and presently, in Japan also, reports of hearing tests performed by means of audiometer are available ad lib.

TAKAHASHI[21] ascertained the presence of residual hearing acuity in 41% of his subjects, KAWAKAMI[22] in 70%, TAKAI[23] in 71.?%, IMURA[24] in 78%, TAKEUCHI[25] in 54%, SHIBANO[26] 78%. HOSHI[27] declared that 40% of his subjects was found to have hearing loss 90 db up, 15% 120 db up, and most of them 80–100db. TSUIKI[28] tested up to 110db and asserted that 5.8% possessed 110db up. OGURA[29] carried out air-conduction and bone-conduction hearing tests, and found that 75% possessed residual hearing acuity. UEDA[36] professes that, of 100 deafs subjected to his test, only 2 were found to be total deaf-mutes.

Although the above researches present some difference in the criteria for determining total deafness, they all indicate the presence of residual hearing acuity in 50–80% of the so-called deaf-mute.

In determining the degree of hearing acuity of the deaf-mute, FOWLER[31] stands firm against the use of it in conversation, if, by his calculating system, their hearing loss amounts to 90%, for such a percentage equals to 75db, and hearing loss 75 db up is regarded by him as total deafness. HUIZINC[33], in his classification of the deaf-mute, is ranking those whose hearing loss counts up to 90 db as total deaf-mutes. In America, it seems a recent trend to treat those whose hearing loss marks 83 db up as total deaf-mutes. In Japan, it has been the custom

to regard those who gave 90 db up as total deaf-mutes. However, HOSHI[27] is opposed to classifying those whose hearing loss marks 90 db up as total deaf-mutes, holding that the deaf-mute respond to sounds of 90 db up. TAKAKI[23] maintains that those whose hearing loss counts 75 db are unable to use their hearing acuity in acquiring speech. Therefore, those who give 75 db up may well be taken as total deaf-mutes.

Viewing the results of the test carried out by this author on 50 deaf children, it is evident that, if 90 db up is made a criterion for total deafness, residual hearing acuity exists in 80% (40 children); if 83 db a criterion in 72% (36 children); if 75db a criterion in 54% (27 children). All these figures agree with those reported by researchers both at home and abroad.

Hearing test and speech acquisition constituting, as it were, two sides of the shield, hearing test of the deaf should be undertaken not only for the residual hearing acuity they may retain, but also for the important part it plays in speech rehabilitation of the deaf.

Looking for reports on the classification of children with hearing disorders made from the viewpoint of speech rehabilitation, we find rather old reports by Itard, F. Bezold, et al. The more recent reports on classification are available as follows.

Classification by I. R. EWING and A. W. EWING[32]:

Grade Ⅰ. Children who are found to have defects of hearing (which in most cases are amenable to medical treatment) but who do not need hearing aids or special educational treatment.

Grade Ⅱ. Children who have some naturally acquired ability to talk but need special educational treatment, on either a part-time or a full time basis. Many of these children need hearing aids.

Grade Ⅲ. Deaf children who are without naturally acquired speech, when admitted to school. Many of these children are not totally deaf and can be helped by hearing aids, in learning to talk and speek distinctly.

Classification by H. C. HUIZING[33]:

Grade Ⅰ. 0−30db slight loss

Grade Ⅱ. 30−60db moderate loss (practical speech span)

Grade Ⅲ. 60−90db severe loss

Grade Ⅳ. More than 90 db deaf (no speech-understanding ability) (hearing aids prove effective in Grade I. II.)

Classification by SILVERMANN[33]:

1. Less than 30 db — lip reading and favorable seating.
2. 30−45 db — lip reading, hearing aid (if suitable) and auditory training, speech correction and conversation, favorable seating.
3. 45−60 db — lip reading, hearing aids and auditory training, training in speech, special language work, favorable seating or special class.

4. 60−80 db — needs the kind of educational procedures for the deaf child, with special emphasis on speech auditory training, and language; with the possibility that the child may enter regular classes.
5. More than 80 db−special class or school. Some of these children eventually enter high schools for hearing.

What is gathered in common from all of these classifications is that children with hearing loss 30−60 db should receive an adequate speech therapy on equipping themselves with hearing aids, and attend hard-hearing classes as well. Hearing aids proving effective in speech education even of deaf children with hearing loss 60−80 db, there is a possibility of there is possibility of their returning to normal classes after receiving speech therapy.

In his observation of the deaf-mute on whom fenestration was effected, SILVERMAN[34] states that hearing loss 30 db will make inconvenience in social life, and 60 db be the maximum hearing acuity practicable without the use of hearing aids.

HNUIZING[33] states that children with hearing loss 25 db may find inconvenience in communication.

In Speech and Hearing Clinic, Nagasaki University School of Medicine, the author has experienced the case of a 3-year old child with speech impediments due to hearing loss 30 db. This experience of the writer testifies to the fact that, in cases of children with hearing disorders, such hearing losses as 30 db, 60 db, 80 db convey a great meaning in their speech rehabilitation.

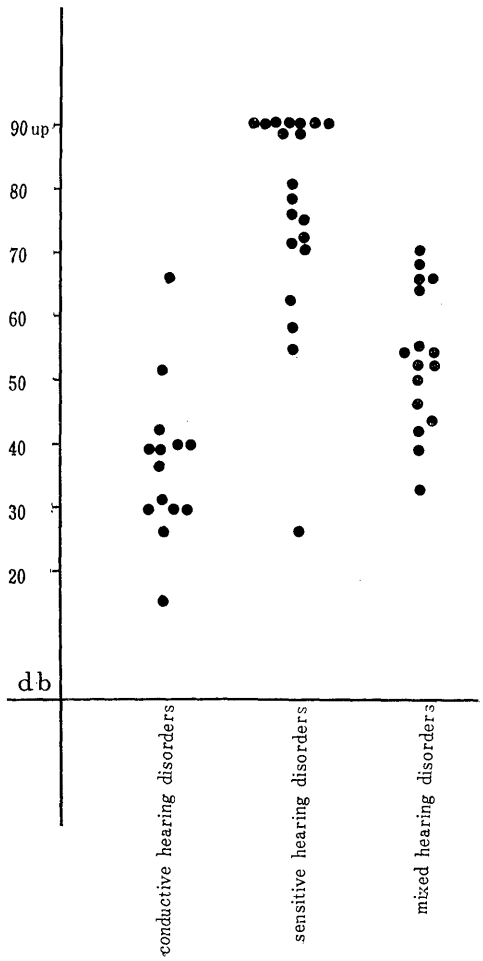
An investigation into the results of the author's test executed on the 50 subjects reveals that those whose hearing loss registered 60 db under, in which use of residual hearing acuity aided by hearing aids proved effective, count 17 (34%). These children are considered to be entitled to attend normal classes or hard-hearing classes. Those children count 15 (30%) whose hearing loss registered 60−80 db, which is considered large enough to warrant possibility of their returning to normal classes, provided that use of residual hearing acuity through the medium of hearing aids is possible and satisfactory attainments are shown in their speech education. That is to say that the above 32 (64%) children must not be educated as total deafs, and that children with hearing loss 45 db need not join special classes, for, with an adequate guidance, they are sure to become entitled to enter normal classes. In the author's test, 7 children were found to have hearing loss 45 db under. All these findings revealing the fact that, in Japan, proper hand of welfare has not been extended to children with hearing disorders, I cannot help saying that children with potential enough to grow to be normal entities are openly subjected to public treatment as the deformed.

*2. Auditory type and Causes of hearing disorder*

Since the establishment of audiometric method of hearing test, auditory types have come to be expressed by the type of audiograms obtained from the test, viz. low-frequency disorders type, level type, high frequency disorders type, convex type, non-measurable type.

Study reports discussing the matter of auditory type of residual hearing acuity existing in the deaf are available but seldom. HOSHI[27] demonstrates that 94% of his subjects proved to be of high-frequency disorders type or level type, and only 2 out of 360 ears tested were found to be of low frequency disorders type. TAKEUCHI[25] reports that low-frequency disorders type was found in 22%, level type in 15%, and only 1 among the 108 ears tested proved to be of low-frequency disorders type. OGURA[29] states that a majority of low-frequency disorders type, acquired deafs occur more frequently than the other.

Table (15)
Hearing loss and classification of hearing disorders

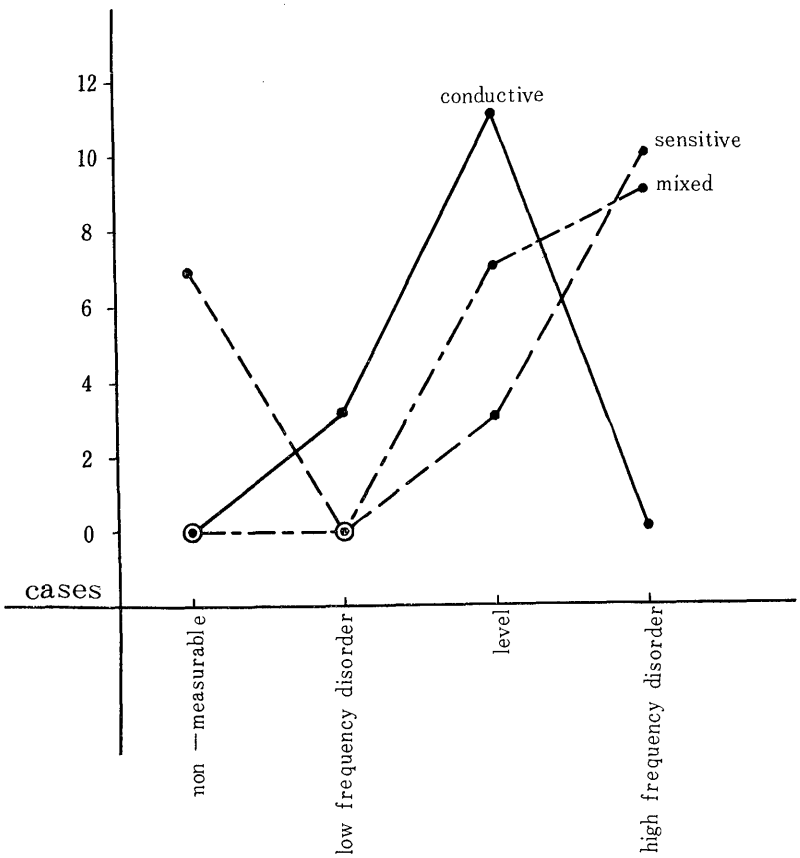



Of the 50 cases investigated by the author, 19 (38%) were found to be of high-frequency disorders type. 21 (42%) of level type, 3 (6%) of low-frequency disorders type, 7 (14%) of non-measurable type. These figures agreeing with those given by various scholars, it may be said with impunity that high-frequency disorders type and level type combined predominate the auditory type of the deaf, whilest low-frequency disorders type is found very seldom.

Precise differentiation of the causes of hearing disorders in the deaf being impossible to undertake, it is considered proper to divide them into 3 classes, viz., sound-conductive hard-hearing, sound-sensation hard-hearing, and mixed hard-hearing.

Taking a comprehensive view of results of the hearing test and otological findings, the author has carried out investigation of hearing disorders of the subjects in accordance with the above classification,

Table (16) Auditory type and classification of hearing disorders




and obtained 14 (28%) cases of what is taken as sound-conduction hard-hearing, 20 (40%) cases of sound-sensation hard-hearing, 16 (32%) cases of mixed hard-hearing.

Interrelation between hearing disorders and residual hearing acuity or hearing type being displayed on Table (15) and Table (16), the fact was known that, in cases of sound-conduction hard-hearing, most of the subjects showed hearing loss 60 db under, their hearing type belonging to level type or low-frequency disorders type, whereas, in cases of sound-sensation hard-hearing, most of the subjects gave hearing-loss 70 db up, thier hearing type being identified with high-frequency disorders type or non-measurable type. Subjects with mixed hard-hearing exhibited hearing loss 50−80db, their hearing type proving similar to high-frequency disorders type or level type.

Explaining by his theory of auditory area the interrelation between hearing disorders and speech acquisition, H. DAVIS[38] states that, of the cycle elements that exist in speech sounds, high-cycle element and low-cycle element are impossible to be secured as sense of hearing. According to

J. C. BALLANTYNE[35] dwelling on the element that presents itself in speech sounds and the sense of hearing during conversation, the former registers 500−2000 cycle, the latter 40−60 db in vowels; 2000 cycle up, 10−40db in consonants. OHSAWA[36] reports that, in the Japanese language, the two factors are seen to mark respectively 500−2500 cycle, 40−70 db in vowel sounds; 2500 − 8000 cycle, 15 − 45db in unvoiced consonant sounds. It is clear from these findings that deafs of low-frequency disorders type feel harder to acquire speech sounds than those of high-frequency disorders type. This revelation in the deaf is to be taken to testify to the fact that the speech sounds of a posteriori deafs, the greater part of whom being of low-frequency disorders type, give less intelligibility than those of a priori deafs, the majority of whom belonging to high-frequency disorders type.

In their reports on the relation between hearing disorders and adaptability for hearing aids, MULLIN, C. J.[37], Maunton, R.F.[38], NAGAHAMA, et al.[39], state that deafs with sound-conduction hard-hearing are possessed of absolute adaptability, and many with mixed hard-hearing are known to have adaptability enough to enable them to hold on even in cases any decrease of intelligibility occurs. As regards cases of sound-sensation hard-hearing, the reporters say that adaptability should be determined case by case. Of the 50 deaf children tested by the author, 14 (28%) proved to possess sound-conduction hard-hearing and hearing loss 60 db, showing that they are absolutely adaptable for hearing aids. These children are sure to be able to attend normal classes after receiving proper speech therapy. Children with mixed hard-hearing showing hearing-loss 50 − 80 db, they have an adaptability for hearing aids, and are well entitled to join normal classes or hard-hearing classes. Of the 20 children with soung-sensation hard-hearing, 16 were detected to have hearing-loss 80 db up, 7 of the 16 proving to be of non-measurable type. With regard to hearing type, high-frequency disorders type was ascertained in 10 cases, only few of them being considered adaptable to hearing aids. However, if 80 db is made the maximum residual hearing acuity practicable, there will be a possibility for 5 children to become object of speech therapy on their being equipped with hearing aids, and return to normal classes, provided that the treatment proves effective.

*3. Articulation and pronunciation intelligibility*

Speech is a means of communication. Therefore, its intelligibility makes an important problem. However, determination of intelligibility of speech sounds has so far been made by hearing, and has naturally been influenced more by the subjective view than objective of the hearer. Formerly, the method was in practice that one single tester listened direct to the speech sounds of his subject, and detected any abnormalities there might be in them. However, there is the question of inurement in such a method, and the results obtained do not always warrant

reliability.

Attempts at objective determination of intelligibility of speech sounds have been rife recently.

In America, such word lists a Central Institute for the Deaf Monosyllabic Word Lists and Harvard Phonetically Balance Monosyllabic Word Lists are in use as model patterns.

In Japan, there are reports by TAKEYAMA[40], KAMAMOTO[41], MORIYAMA[42], TAGUCHI[43], NAKAMURA[44], TAKAKI[23], SHIBANO[26], EGUCHI[45] on the articulation and pronunciation intelligibility of the deaf. These reports are more or less different in their method, but, as a whole, they show that, in speech learning, it is difficult to attain an intelligibility 40 – 50 % by lip reading alone, the mean value of intelligibility indicating 20 – 30%. According to the reports, increase of training years does not go parallel with improvement of intelligibility, the maximum degree of intelligibility being attained in the first 3 years of training. The reports also say that the bigger the size of residual hearing acuity is, the higher the degree of intelligibility grows, and that, if speech education by lip reading and use of residual hearing acuity is started in early childfood, acquisition of intelligibility 80% up will be realized.

Every spoken language of the world has its own way of articulation, rhythm and intonation. Therefore, methods of articulation test employed abroad, are not applicable to spoken Japanese.

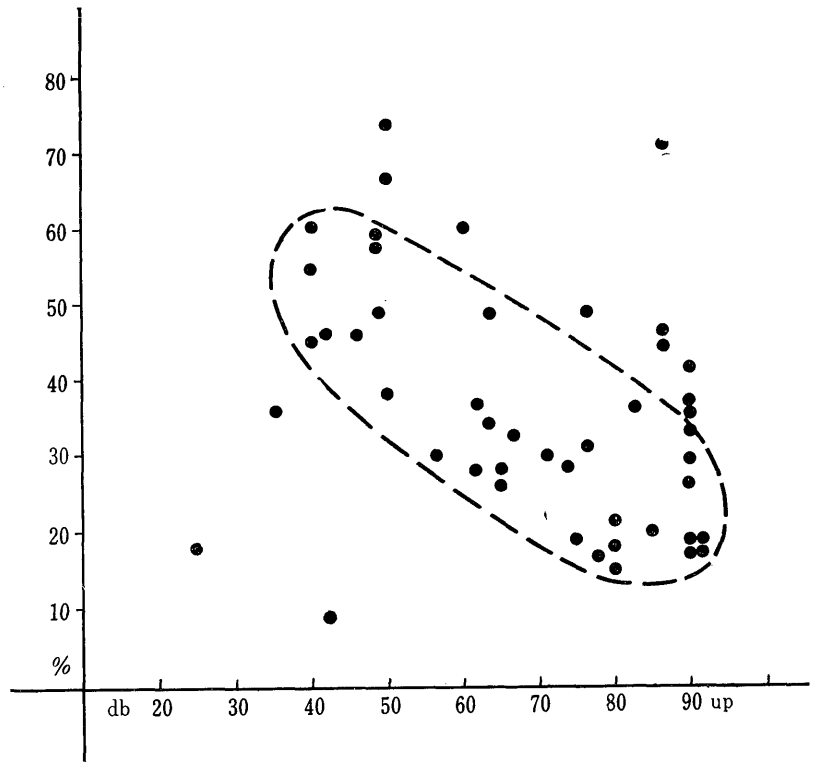
A laborious study on articulation and pronunciation intelligibility test of spoken Japanese is reported by FURUYA[46]. According to him, even if the test sounds are the reproduction of tape-reccorded sounds, results warranting clinical reliability will be obtained, the maximum reliability value recording $-2.23 \pm 1.094\%$.

On the other hand, OKAMOTO[47], in his report on hearing intelligibility test, states that, in case of speech sounds registering 60 phons about the tester's ear, the probable errors of hearing intelligibility by the normal ear will not exceed $\pm 3\%$.

Again, FURUYA[46], reporting on the calculating system of articulation and pronunciation intelligibility, says that the probable errors of intelligibility will not exceed $-5\%$, if arithmetical mean of the medium 3 percentage values given by 3 of the 5 testers is taken as calculating standard, the maximum and minimum percentage vrlues given by the other two being excluded. Therefore, articulation and pronunciation intelligibility test conducted by this author warrants reliability.

An investigation into the results obtained by the author reveals that 22% (11 cases) of the subjects showed an intelligibility 31 – 40%, and exceeded all others in number. This result is seen to correspond with that reported by the various researchers. Another phenomenon that presented itself in this test is that 82% (41 cases) gave intelligibility 50 %, wheseas only 18% (9 cases) marked 50% up. This is considered to

Table (17) Articulation & Pronunciation Intelligibility and residual hearing acuity




testify to the fact that, in speech learning by lip reading alone, intelligibility 50% makes the maximum value.

Articulation and pronunciation intelligibility and residual hearing acuity being displayed on Table (17), existence is noted of correlation between these 2 elements. This fact indicates that residual hearing acuity proves to be the most prominent of all the factors that exercise influence on speech articulation intelligibility.

Many studies on the causes of deficient intelligibility are underway in different centers of the world. In countries overseas, Hudgins, C. V. et al[48]., Rawling, G[49]., Voelker, C. H[50]., Gutzmann, H[51]., Sokolowsky, R[52]. are devoted to the study on respiration curve, vital capacity, rhythm, vocal register, phonation time. In Japan, Tatsumi[4], Honda[7], Masuda[10], Fujita[53] are working on the same themes. These scholars have been successful in clarifying the absence of concerted action between sound production and articulation movements. According to their reports, this absence of concerted action causes excessive waste of expiration, less rhythm change, quadrupling of normal phonation time, frequent occurrences of hoarse voice, manifest instability of vocal range. These

symptoms developing decrease of intelligibility, the cause of this phenomenon is held to be attributable to absence of feedback mechanism. The reports also say that even a slight residual heaing acuity that may have been retained by the deaf will produce a favorable effect on such defectiveness. Paradoxically speaking, this agrees with the fact that the bigger the size of residual hearing acuity is, the higher the degree of intelligibility grows.

An investigation into the relation of phonetical classification of speech sounds with their intelligibility reveals that voiceless sounds give the highest degree of intelligibility, voiced and semivoiced sounds a less degree, contracted sounds the least. As described in the foregoing discussion, if the frequency zone of spoken Japanese displayed by OHSAWA[36] and the energy of speech sounds during ordinary conversation that was recorded on audiogram by J. C. Ballantyne[35] are taken into consideration, the fact is confirmed that vowel sounds and voiceless sounds are not accurately caught by the ear, voiced and semi-voiced sounds less accurately, contracted sounds least accurately.

With regard to articulation points and relative intelligibility, labial sound, dental sound, palatal sound, aspirate sound each presented a less degree of intelligibility in the above order. This result also agreeing with that reported by Takeyama, the fact is revealed that intelligibility goes parallel with visual perception of articulation movements. The fact that elastic sounds surpass all other sounds in intelligibility may be attributable to the articulation movements being easily caught by the eye. No remarkable difference in intelligibility is recognized among nasal sounds, plosive sounds, fricative sounds. This may be due to the fact that, these sounds each presenting very similar articulation movements, it becomes necessary to resort to hearing factors in order to distinguish between their degrees of intelligibility. That plosive-fricatives develop the least intelligibility is considered to come from the fact that as emission of this kind of sounds demands an articulation movement midway between plosives and fricatives, observation becomes difficult to make, and, in addition, the size of articulation motion itself of plosive-fricatives is small.

*4. Mishearing trend of deaf-speech*

The question of how the deaf-speech is misheard conveys a great meaning in the practice of speech therapy.

TAKEYAM[40] reports that frequence of mishearings is big in the speech sounds of the third articulation point (K, g. etc), less in those of the second, still less in those of the first. RYU[8], treating of the question of mishearing trend, gives the following formulae: K→nK, T →t+a, R→aR. KAMAMOTO[41] reports that, whereas K, T, P sounds exhibit a fair degree of intelligibility, Sh and voiced consonants are liable to mishearing.

Based on the observation made of a case in which exhibition of an

early-stage speech therapy using hearing aids proved successful, EGUCHI [45] report that an intelligibility 84% has been obtained, mishearing tending to occur between each speech sound of the same articulation point.

What all these reports say is that, although the deaf can catch the articulation movements by lip-reading, the slight difference in the articulation movements discernible during emission of speech sounds proves a phenomenon too difficult for them to catch.

In the author's test, mishearings were observed to take place not between sounds of a monosyllable series, but between sounds of the different monosyllable lines, indicating that the deaf are hard of articulating the speech sounds of the monosyllable lines. This phenomenon is due to the fact that, through, of the elements that constitute a speech sound, the succeeding vowel sound is accurately learned, the preceeding consonant wave (spike fill and fill) is but inadequately acquired. In other words, it may be said that speech learing proves of hard training on the deaf's part because the spike fill and fill are not only of brief duration but also of weak energy.

*5. Conversation Intelligibility*

Articulation intelligibility test has been in use as a means of judging the speech faculty of aphasiacs. In case of the deaf, however, test by monosyllables is, in a way, not to be considered an adequate method of examining the intrinsic value of the faculty. The reason for this may be that speech disorder is not the product of abnormal articulatory organs developed a posteriori, but difficulties the deaf find in speech learning itself at their growing stage, the sole purpose of deaf education consisting in fostering them as members of society capable of communication. In this meaning, conversation intelligibility test of the deaf proves of great importance. In his effort to suit such a purpose, therefore, Taguchi has made the presentation of a test sentence list as previouslydecribed. So far, reports of conversation intelligibility test performed have been available but seldom. According to TAGUCHI[43], conversation intelligibility and articulation intelligibility display a similar tendency. TAKAKI[23], on carrying out an experiment similar in kind to that done by Taguchi, professes that many of the acquired deaf were found to possess a goodly amount of conversation intelligibility, whereas many of the congenital presented a poor amount.

TAKAKI[23] also says that existence was recognized of interrelation between residual hearing acuity and conversation intelligibility.

In the authors test, 29 (58%) cases gave an intelligibility small enough to be considered to cause inconveniences in their daily life, and this fact supplies cues for thinking that approximately half of the deaf-mute will come to have a possibility for rehabilitation after speech

learning by lip reading alone. Regarding the relationship between residual hearing acuity and articulation intelligibility or conversation intelligibility, results obtained display a rough correspondence with each other. As is described in many reports dealing with the relation of the congenital or acquired deaf with residual hearing acuity, the phenomenon was observed that many of the congenital deaf had retained a sizable amount of residual hearing acuity. It is therefore confirmed that this finding agrees with the view that the congenital deaf exhibit a better intelligibility than the acquired.

Dwelling on the interrelation between articulation intelligibility and speech faculty, FURUYA[46] has established the following classification :

| Artic. Intel. | Convers. Intel. | Judgment |
|---|---|---|
| 97−100% | normal | |
| 71−96 | slight difficulty | generally intelligible |
| 36−70 | medium 〃 | unintelligible unless repeated once or twice |
| 0−35 | grea 〃 | almost unintelligible |

The following is the result of the author's test as applied to the above classification :

| | | |
|---|---|---|
| normal | 0 | |
| slight difficulty | 2 | cases |
| medium 〃 | 22 | 〃 |
| great 〃 | 26 | 〃 |

According to the judgment criterion set by the author, "great difficulty" corresponding with Grade IV or V, the deaf children coming under Grade I, II, III, who are capable of rehabilitation, count 24.

It is easily deducible from the above findings that approximately half of the deaf will make no improvement in their speech faculty, even if they get speech learning by lip reading, and accordingly find difficulty in communication in their daily life.

*6. Sound Spectrographic Studies*

Since the introduction in 1946 of sound spectrograph as a heraldic device for studing speech sounds, it has been in extensive use by phonic students for the same purpose.

This device can display in a three-dimension pattern the three elements, frequency, energy, time, which are inherent in speech sounds.

Abroad, R. K. POTTER et al[54]., FAIRBANK, G et al[55]., at home, IMAI[56], KAMAMOTO[57], HIRANO[58], MIYANO[59], SEKI[60], HATTORI[61], YANAGINO[62], are all employed in the study of normal as well as various abnormal speech sound. Notwithstanding this, there are extremely few spectrographic studies available on the deaf speech.

MORLEY, D. E[63]., studying on the consonant sounds of the deaf speech, has presented his view of the existence of relativity between distortion and intelligibility of the consonant sounds.

WATSON, T.J[64]., making a comparative study of the sonagram of normal speech sounds and that of abnormal ones, says: "The consonant prediction was slightly better than that of the vowel, and that hearing for the first two formants seemed of more significance than hearing for all three formants".

A. A ANGELOCCI et al[65]., examining the vowel sounds of normal and deaf children 11−14 years of age, reports that "higher mean fundamental frequencies for all vowels, mean ranges of fundamental and amplitudes were greater for the deaf, mean ranges of first three formant frequencies and amplitudes were greater for the normal hearing"

In Japan, there are no other studies available on the subject than those by IMAI[66], SUHARA[67], FUJITA[53].

IMAI[66], making observation on the vowel formant, points out the fading phenomenon of its characteristics.

SUHARA[67], carrying out an investigation into the pitch and spectrum of the vowel sounds of both normal and deaf children, reports that, with the increase of hearing loss, there occur the decrease of the first and second formant into the low cycle range, the weakening of energy of the high cycle range elements, and the lowering of the pitch; all these are due to lack of coordination of articulation movements of speech sounds with increase of hard hearing.

FUJITA[53] demonstrates increase of the first formant, decrease of the high grade formants, and, as a whole, their shift into the low cycle range. The cause for this, he explains, lies in the residual hearing acuity of the deaf being great in the low cycle range.

Every speech language of the world has its own way of articulation. In this connection, the author has undertaken a comparative of the normal Japanese people as reported by HATTORI[58] and SEKI[60].

The results obtained agree with those reported by the various researchers in the point that, in vowel sounds, decrease was evident of the first and second formant into the low cycle range, and fading was noticeable of all the formant characteristies from the 5 vowel sounds. In the author's view, the fact that the deaf's way of pronunciation shows similar aspects among the 5 vowels may have given rise to there findings.

In the consonant sounds, such articulation phenomena observed as reduction, extention, disappearance, division of the consonant wave, as well as diminution, expansion, fading of the transitional part testify to it that these are anomalous aspects produced by the deaf's attempt at learning speech by watching the articulation behavior of their teachers. These anomalies are considered to arise from the imperfect acquisition of two elements, time and energy, out of the three that are inherent in speech sound.

The following is the author's view on sonagraphic anomalies and mishearings of speech sounds.

K−series :
Disappearance of consonant wave → A−series
Division, extension of consonant wave
Diminution, obscurity of transitional part } → G−series
S−series :
Diminution, extension of consonant wave
Obscurity of transitional part } → Sha−series / Zha−series
T−series :
Division of consonant wave
Existence of fill
Obscurity of transitional part } → S−series
Decrease of consonant wave
Nasalization } → D−series
R−series :
Disappearance of consonant wave
Existence of fill in transitional part } → Y−series
Mixture of spike with consonant part → Ry−series

The above mishearings presenting a similar trend not only to that of the author's articulation intelligibility test, but to the report by MORLEY, D. E[63]., it is considered that these findings are the anomalous products of the deaf's unconsciousness of their own false speech sounds and the resultant incapacity for self-coordination.

On the other hand, a comprehensive survey on the vowel and consonant sounds revealed that, in addition to the cycle element, the souffle elements was detected on the sonagram of nearly all of the cases. This is thought to have come from imperfect exercise of coordination process among respiration, vocalization, articulation. A more detailed examination of the laryngeal functions might reveal the existence of anomalous vocal cords originated in these imperfect coordination processes. MASUDA[10], examining the larynx of the deaf, has ascertained the existence of abortion, rubefaction, atrophied vocal cards, excessive secretion, and attributed their causes more to the anomalous tension than to the disparity of both cords. This murmur element the author has get in the sonagram is to be taken to testify to these symptoms.

The murmur element of the deaf speech shall remain a subject of continuous study for the author.

All the facts pointed out in the present discussion may assert that they have originated in the lack of proper self-coordination because of the unemployment of hearing in speech learning.

Anomalies in speech sounds, be they demonstrated analytically, may not be taken to constitute a direct cause of the decrease of their intelligibility. Therefore, based on the 4-grade judgment criterion of my own creation, the author has carried out a combined test of sonagraphic findings and intelligibility of speech sounds, the result showing that the

greater the residual hearing acuity is, the better the sonagraphic findings and speech intelligibility become, that this same relation exists between residual hearing acuity and articulation intelligibility or conversation intelligibility. This is true of speech learning by lip reading, too, in which case the deaf with residual hearing acuity will catch the cycle element in speech sounds through it, and exercise self-coordination on the articulation process.

It is an evident matter that, with the additional use of hearing aids, a good speech faculty will be obtained.

*7. Cinefluorographic slow motion picture findings*

There is a multitude of studies on the normal as well as the abnormal state of articulation carried out by use of radiography, but extremely few are available on the abnormal articulation of the deaf. Especially, we are totally devoid of studies to which the slow motion picture film has been applied.

Every spoken language of the world has its own way of articulation process, and, in addition, presents extremely fine movements in a flash of time. It is therefore impossible to make a full observation of the whole proceeding by one single film portraying an instant action. In this meaning, the motion film must prove of great use for testing purposes.

R. L. SHELTON[68] made an investigation into the normal articulation movements through the films he had taken at two different speeds, 24 frames/sec. and 64 frames/sec. He is of the opinion that the slow motion film proves handy for plotting the movements.

In the author's test, degrees of abnormal articulation were found to have a counter-trend to those of residual hearing acuity and intelligibility. This phenomenon may be taken to show that one phase of the sound singularity of the deaf speech was evidenced as an anomalous aspect of the articulation movements.

Needless to say, this has originated in the unsatisfactory self-control of articulation manners developed by loss of feedback mechanism. Dealing with individual cases of the abnormal state of articulation, the fact is noted that, in vowels, the flat-backed tongue or the cylinder-backed one forms an anomalous resonance cavity, which is considered to explain the appearance of formant disorders in the sonagram. This explains the development of "rigidity of the tongue" pointed out by the asylum teachers, and should be understood to verify the lesson that the first step toward the betterment of intelligibility of the deaf speech consists in the auditory training; that another important thing in the speech education of the deaf lies in their articulation training in the natural state. In consonants, anomalies in the articulation point are considered to cause division, extension, decrease, disappearance, murmurization of the consonant wave as displayed in the sonagram. The

phenomenon of decrease in motility of the tongue in the pronunciation of the succeeding vowel sounds may account for disappearance, diminution, expansion, murmurization of the transitional part as displayed in the sonagram.

Although the anomalous articulation process treated above may prove the cause for the deaf's abnormal speech sounds, this alone does not provide enough evidence to cover the whole cause of anomalous articulation of the deaf; it should be regarded only as a model pattern. Of course, these are unavoidable disorders incidental to speech learning by sight. In order, therefore, to diminish these disorders, what little amount of residual hearing acuity the deaf may retain should be made use of with due regard to the fact that the more the residual hearing acuity is, the less the articulation disorders become. This will prove of great significance in the speech education of the deaf.

*8. Question of Speech Therapy for Children with Hearing Disorders*

Speech therapy for children with hearing disorders is an urgent question of great significance. The author has carried out a systematic study of the speech faculty of Japanese deaf children, and come to know of every phase of its existing state. The result obtained teaches us that, if the educational method presently in use is continued, improvement in the speech faculty with prove of forlorn hope. A fundamental reform of the deaf education in this country is urgently called for.

In Japan, the speech education for the deaf begins with their admittance to the primary school. As regards to the age for starting the speech education, H. BEZOLD[12] has recommended it in the early childhood. In foreign countries, importance of the early speech therapy has also been recognized and put into practice. Bezold, which, in this country, it has been neglected until quite recently, but recognition is beginning to be accorded now.

In the normal children, speech faculty will show its first sign of development in 9–12 months after birth, make a rapid growth in about 18 months, and, in about 36 months, attain such a degree as to enable them to speek daily words of their own. Indeed, this is the best period of time for children to learn speech. TRAVIS[33] asserts that this is the best period of time to give speech education, calling it the period of "readiness". Therefore, if, in this period, hearing disorders have existed in them, the children will turn out deafs, because their speech learning will prove a matter of impossibility.

On the other hand, the function of the auditory speech center is said to develope and differentiate by the incessant reception of the auditory speech stimulus; therefore, in case the children have been blessed with no such changes during the first 5 years of their life, resuscitation of such function is said to be almost impossible. A good explanation of this may be found in "Wild Boy of Aberon"; that is to

say that speech training begun at the time of the children's admittance to the primary school will not bring about any satisfactory results, so that speech training should be started simultaneously with auditory training in their infancy, at least, at the age of 2 or 3.

In this meaning, HUIZING, H. C[70]. gives the name of 'acoupedic treatment' (audiological education) to the early speech therapy for children hard of hearing, and asserts that the treatment proves absolutely effective on children with residual hearing acuity.

Studies on cases in which normal education was possible after an early speech therapy are available but seldom, except those reported by BEEBE, H.H[69]., HUIZING, H.C[70]., TAKAKI[23], EGUCHI[45]. However, the fact that, university education is being given to the deaf in America may point to the existence of a multitude of such cases.

Referring to the application of residual hearing acuity to the speech therapy, BEZOLD, H[12]. has already stressed its necessary in the deaf therapeutics, but, in practice, this has been no easy task to undertake. However, the advent of precise hearing aid has become an indispensable in speech training. Especially, in the auditory training, the instrument proves of great service.

There are innumerable studies abroad reporting on the good results obtained by speech training through the use of hearing aids.

HUIZING, H. C[70]., on making a deliberate comparison of the speech faculty of the deaf who has undergone the speech training by lip reading alone with that of one trained with the help of hearing aids, reports that the latter has demonstrated approximately 100 times as much as the former, that a better result has been obtained in the case of an infant on whom the acoupedic treatment was started 16 months after birth, some 50 speech words being acquired by one and half years' speech training.

In Japan, it is the current practice for asylum teachers to conduct speech training without use of the residual hearing acuity, and, accordingly, there are but few reports on the theme, except only those by TAKAKI[23], EGUCHI[45].

Needless to say, the important role the residual hearing acuity plays in the speech learning of the deaf lies in its potentiality to form feed back mechanism, and thus to try the normal state of speech learning as far as possible. The phenomenon that the increase of residual hearing acuity is compatible with the progress of speech acquisition, which was also revealed by the author's test will testify to it that what little amount of residual hearing acuity the deaf may retain will favorably affect their speech learning. In other words, this means the confirmation of the effectiveness of acoupedic treatment.

Making a comprehensive survey on the whole course of his test, the author has come to the conclusion that the future speech rehabili-

tation of the deaf should take its course toward the acoupedic treatment in their infancy as proposed by H. C. HUIZING[32].

## CONCLUSION

The author investigated systematically 50 deaf children who have been given speech education by lip reading alone and obtained the following facts.

1) If 90db up is made a criterion for total deafness, residual hearing acuity exists in 80% (40 cases); if 83db a criterion in 72% (36 cases); if 75db a criterion in 54% (27 cases).

2) Hearing loss registering 60 db under, in which use of residual hearing acuity aided by hearing aid proved effective, count 34% (17 cases). Those children count 30% (15 cases) whose hearing loss registered 60 – 80 db, which is considered large enough to warrent possibility of their returning to normal classes provided that use of residual hearing acuity through the medium of hearing aid is possible. Seven childeren were found to have hearing loss 45 db under, they are sure to become entitled to enter normal classes.

3) 19 cases (38%) were found to be of high frequency disorders type, 21 cases (42%) of level type, 3 cases (6%) of low frequency disorders type, 7 cases (14%) of non-measurable type.

4) 14 cases (28%) were taken as sound conduction hard hearing. 20 cases (40%) of sound sensation hard hearing, 16 cases (32%) of mixed hard hearing.

5) In cases of sound conduction hard hearing most of the subjects showed hearing loss 60 db under, in cases of sound sensation hard hearing they gave hearing loss 70 db up. Subiects with mixed hard hearing exhibited hearing loss 50 – 80db. Subjects of sound conduction hard hearing and mixed hard hearing should be given acoupedic treatment.

6) In articulation and pronunciation intelligibility, ll cases (22%) showed an intelligibility 31–40%, 41 cases (82 %) gave an intelligibility 50% under. This is considered to testify to the fact that speech training by lip reading alone, intelligibility 50% makes the maximum value.

7) There exists a significant correlation among articulation and pronunciation intelligibility, and residual hearing acuity.

8) An investion of the relation of phonetical classificationof speech sounds with their intelligibility reveals that voiceless sonnds give the highest degree of intelligibility. voiced and semivoiced soundsa less degree, contracted sounds the least.

9) With regard to articulation points and relative intelligibility, labial sound, dental sound. plalatal sound, and aspirate sound presented a less degree of intelligibility in the above order.

10) In articulation movements and intelligibility, elastic sounds surpass all other sounds and no remarkable differenc is recognized among nasal sounds, plosive sounds, and fricative sounds.

11) Mishearings were observed to take place in sounds of the diff-crent monosylable lines. This phenomenon is due to the fact that the corsonant wave is inadepuately acpuired.

12) Regarding the relationship between residual hearing acuity and articulation intelligibility or conversation intelligibility, results obtained display a correspondence with each other. Subjects of conversation intelligibility grade III−V were 29 cases (58%). These childrens find difficulty in communicating in their daily life.

13) Sonagram findings, in vowels, decrease was evident of the first and second formant into the low cycle range, and fading was noticeable of all the formant characteristics from the 5 vowel sounds. In the consonant sounds, such articulation phenomona observed as reduction, extension, disappearance, division of the consonant wave, as well as diminution, expansion fading of the transitional part were observed and murmur elment was proved in almost all sonagram.

14) Relationship between sonagraphic anomalies and mishearings were confirmed.

15) Results of combined test of sonagraphic and speech intelligibility have some relation with residual hearing acuity and articulation intelligibility or conversation intelligibility.

16) Regarding to cinefluorographic finding of articulation mevement, the fact is noted that, in vowels, the flat-backed tongue or the cylinder-backed tongue, articulation point; in consonants, articulation point moved forward or backward, enlarged or broken into two parts, undetected; cylindrical form for lack of sufficient motility of the tongue.

17) Degree of abnormal articulation were found to have a counter trend to those of residual hearing acuity and intelligibility.

18) It is revealed that anomalies of articulation correspond to those of consonant wave in sonagram, and lack of sufficient motility of the tongue in articulation of succeeding vowels to anomalies of transitional part in sonagram of consonant.

19) Of course, these findings may be unavoidable disorders incidental to speech learning by lip reading alone, in order to diminish these disorders, acoupedic treatment should be given, and residual hearing acuity be used in speech therapy from early childhood.

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